Claims

What is claimed is:

1. A method for operating a compression ignition engine having a cylinder wall, a piston, and a head defining a combustion chamber, comprising the steps of:

delivering fuel substantially uniformly into the combustion chamber, the fuel being dispersed throughout the combustion chamber and spaced from the cylinder wall;

delivering an oxidant into the combustion chamber sufficient to support combustion at a first predetermined combustion duration; and

delivering a diluent into the combustion chamber sufficient to change the first predetermined combustion duration to a second predetermined combustion duration different from the first predetermined combustion duration.

2. A method, as set forth in claim 1, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of delivering a substantially homogeneous distribution of fuel into the combustion chamber.

3. A method, as set forth in claim 1, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of delivering fuel into the combustion chamber such that fuel does not impinge on the cylinder wall.

4. A method, as set forth in claim 1, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of injecting fuel in at least one pattern indicative of a desired angle of dispersion.

5. A method, as set forth in claim 4, wherein injecting fuel in at least one pattern includes the step of injecting fuel in at least one pattern with respect to a geometry of the piston.

6. A method, as set forth in claim 4, wherein injecting fuel in at least one pattern includes the step of injecting a first portion of fuel at a first angle of dispersion and injecting a second portion of fuel at a second angle of dispersion.

7. A method, as set forth in claim 4, wherein injecting fuel in at least one pattern includes the step of injecting fuel through a nozzle of an injector having a plurality of holes arranged to inject fuel in at least one pattern.

8. A method, as set forth in claim 4, wherein injecting fuel in at least one pattern includes the step of injecting fuel in a plurality of predetermined patterns.

9. A method, as set forth in claim 8, wherein injecting fuel in a plurality of predetermined patterns includes the step of injecting fuel at a plurality of predetermined angles of dispersion.

10. A method, as set forth in claim 7, wherein injecting fuel through a nozzle of an injector includes the step of injecting fuel through a plurality of micro-sized holes arranged on the nozzle such that fuel is injected in a plurality of predetermined patterns.

11. A method, as set forth in claim 1, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of

delivering fuel into the combustion chamber in the range of about 50 degrees before top dead center to about 180 degrees before top dead center.

12. A method, as set forth in claim 11, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of delivering fuel into the combustion chamber in the range of about 60 degrees before top dead center to about 70 degrees before top dead center.

13. A method, as set forth in claim 1, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of delivering fuel into the combustion chamber in the range of about 30 degrees before top dead center to about 90 degrees before top dead center.

14. A method, as set forth in claim 13, wherein delivering fuel substantially uniformly into the combustion chamber includes the step of delivering fuel into the combustion chamber in the range of about 40 degrees before top dead center.

15. A method, as set forth in claim 1, wherein delivering an oxidant includes the step of delivering a quantity of fresh air into the combustion chamber.

16. A method, as set forth in claim 1, wherein delivering an oxidant includes the step of delivering a quantity of oxygen into the combustion chamber.

17. A method, as set forth in claim 16, wherein delivering a quantity of oxygen includes the steps of:

providing a quantity of fresh air;

separating a quantity of oxygen from the fresh air; and
delivering the oxygen into the combustion chamber.

18. A method, as set forth in claim 1, wherein delivering a diluent into the combustion chamber includes the step of delivering a diluent comprised of at least one of air, nitrogen, and recirculated exhaust gas.

19. A method, as set forth in claim 1, wherein delivering a diluent into the combustion chamber includes the step of delivering a diluent having at least a portion of recirculated exhaust gas.

20. A method, as set forth in claim 19, wherein delivering a diluent having at least a portion of recirculated exhaust gas includes the step of delivering a diluent which includes recirculated exhaust gas from about 40 to about 60 percent of a total quantity of exhaust gas.

21. A method, as set froth in claim 1, wherein delivering a diluent into the combustion chamber includes the step of delivering a diluent having at least a portion of nitrogen.

22. A method, as set forth in claim 21, wherein delivering a diluent having at least a portion of nitrogen includes the steps of:
providing a quantity of fresh air;
separating a quantity of nitrogen from the fresh air; and
delivering the nitrogen into the combustion chamber.

23. A method, as set forth in claim 1, wherein delivering a diluent sufficient to change the first predetermined combustion duration to a second predetermined combustion duration includes the step of delivering a

diluent sufficient to change the first predetermined combustion duration to a second predetermined combustion duration having a value greater than the first predetermined combustion duration.

24. A method, as set forth in claim 1, wherein delivering a diluent into the combustion chamber includes the step of delivering a diluent into the combustion chamber sufficient to change a first predetermined pressure rise rate to a second predetermined pressure rise rate different from the first predetermined pressure rise rate.

25. A method, as set forth in claim 24, wherein delivering a diluent into the combustion chamber sufficient to change a first predetermined pressure rise rate to a second predetermined pressure rise rate includes the step of delivering a diluent into the combustion chamber sufficient to change a first predetermined pressure rise rate to a second predetermined pressure rise rate having a value less than the first predetermined pressure rise rate.

26. A method for operating a compression ignition engine having a cylinder wall, a piston, and a head defining a combustion chamber, comprising the steps of:

delivering fuel substantially uniformly into the combustion chamber, the fuel being dispersed throughout the combustion chamber and spaced from the cylinder wall;

delivering an oxidant into the combustion chamber sufficient to support combustion at a first predetermined pressure rise rate; and

delivering a diluent into the combustion chamber sufficient to change the first predetermined pressure rise rate to a second predetermined pressure rise rate different from the first predetermined pressure rise rate.

27. A method, as set forth in claim 26, wherein delivering a diluent into the combustion chamber includes the step of delivering a diluent into the combustion chamber sufficient to change a first predetermined combustion duration to a second predetermined combustion duration different from the first predetermined combustion duration.

28. A method, as set forth in claim 26, wherein the second predetermined pressure rise rate is less than the first predetermined pressure rise rate.

29. A method, as set forth in claim 27, wherein the second predetermined combustion duration is greater than the first predetermined combustion duration.

30. A method for delivering fuel into a combustion chamber of a compression ignition engine, the combustion chamber being defined by a cylinder wall, a piston, and a head, comprising the steps of:

delivering the fuel to a nozzle of an injector, the nozzle having a plurality of holes distributed in a desired pattern; and

injecting the fuel through the nozzle holes into the combustion chamber in a predetermined spray pattern so that the fuel is dispersed throughout the combustion chamber and spaced from the cylinder wall.

31. An apparatus for operating a compression ignition engine having a cylinder wall, a piston, and a head defining a combustion chamber, comprising:

a fuel injector having a nozzle positioned to inject fuel in a dispersed pattern throughout the combustion chamber and spaced from the cylinder wall; and

an air supply system for delivering at least one of an oxidant and a diluent into the combustion chamber.

32. An apparatus, as set forth in claim 31, wherein the fuel injector nozzle includes a plurality of holes configured to inject a substantially homogeneous distribution of fuel into the combustion chamber such that fuel does not impinge on the cylinder wall.

33. An apparatus, as set forth in claim 31, wherein the air supply system is configured to deliver an oxidant into the combustion chamber sufficient to support combustion at a first predetermined combustion duration and at a first predetermined pressure rise rate.

34. An apparatus, as set forth in claim 33, wherein the air supply system is configured to deliver a diluent into the combustion chamber sufficient to change the first predetermined combustion duration to a second increased predetermined combustion duration, and to change the first predetermined pressure rise rate to a second decreased pressure rise rate.

35. An apparatus, as set forth in claim 31, wherein the air supply system includes:

an air source; and

a turbocharger system for receiving air from the air source and providing at least one of the oxidant and the diluent at boost pressures sufficient for substantially homogeneous combustion.

36. An apparatus, as set forth in claim 35, wherein a sufficient boost pressure is at least about 4 to 1.

37. An apparatus, as set forth in claim 36, wherein a sufficient boost pressure is at least about 4.5 to 1.

38. An apparatus, as set forth in claim 35, wherein the air supply system includes an intake air separation system for receiving a supply of air and responsively providing a supply of oxygen and nitrogen as a respective oxidant and diluent.